

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1042	(substrate or wafer) and (chuck with heater)	US-PGPUB; USPAT	OR	ON	2005/04/07 15:35
L2	1018	1 and temperature	US-PGPUB; USPAT	OR	ON	2005/04/07 15:36
L3	678	2 and (deposition or depositing or deposit)	US-PGPUB; USPAT	OR	ON	2005/04/07 15:37
L4	579	3 and @ad<"20030513"	US-PGPUB; USPAT	OR	ON	2005/04/07 15:37
L5	501	4 and (temperature with (wafer or substrate))	US-PGPUB; USPAT	OR	ON	2005/04/07 15:38
L6	372	5 and ((control or controlling or controlled) with temperature)	US-PGPUB; USPAT	OR	ON	2005/04/07 15:54
L8	103	6 and target	US-PGPUB; USPAT	OR	ON	2005/04/07 15:54

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TITLE: Full area temperature controlled electrostatic chuck and method of fabricating same

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Abstract Text - ABTX (1):

A semiconductor wafer support assembly and method of fabricating the same are provided. In one embodiment, the method and resulting assembly include attaching a pedestal joining-ring to a bottom surface of a ceramic puck. Low temperature brazing a composite cooling plate structure to the bottom surface of the ceramic puck, where the pedestal joining-ring circumscribes the composite cooling plate structure. Thereafter, a pedestal is electron-beam welded to the pedestal joining-ring.

TITLE - TI (1):

Full area temperature controlled electrostatic chuck and method of fabricating same

Brief Summary Text - BSTX (3):

The invention relates generally to an apparatus for retaining a workpiece on a workpiece support within a semiconductor wafer processing system and, more specifically, to an improved three piece wafer support assembly for retaining and temperature regulating large diameter (300 mm or more) semiconductor wafers.

Brief Summary Text - BSTX (5):

In semiconductor wafer processing equipment, electrostatic chucks are commonly used for clamping 200 millimeter (mm) wafers to a pedestal during processing. Electrostatic chucks typically clamp a workpiece (i.e., a semiconductor wafer) by creating an electrostatic attractive force between the wafer and the chuck. A voltage is applied to one or more electrodes in the chuck so as to induce oppositely polarized charges in the wafer and electrodes, respectively. The opposite charges pull the wafer against the chuck, thereby retaining the wafer. For example, in a physical vapor deposition (PVD) chamber a 200 mm wafer is electrostatically clamped to an electrostatic chuck disposed of a wafer support assembly, to ensure that the wafer is stationary and

temperature regulated during processing.

Brief Summary Text - BSTX (6):

Increased demand for 200 mm wafers led to improvements in chuck construction and features for processing this size workpiece. This resulted in higher wafer yield, better temperature control during wafer processing, and an overall better quality product. The latest generation of semiconductor wafers has a diameter of 300 mm, which accommodate fabrication of even more integrated circuit components on a single wafer. Unfortunately, the larger size wafers and smaller device dimensions carry with them their own set of production problems.

Brief Summary Text - BSTX (7):

For example, wafer processing temperatures as low as -60.degree. C. may be required. As such, a larger thermal transfer element (e.g., cooling plate) is required to provide adequate cooling of a 300 mm wafer during processing. Additionally, maintaining adequate and uniform thermal conductivity between the thermal transfer element and the backside of the wafer at any operating temperature is desirable. For example, during pre-wafer process bake-out of the chamber and electrostatic chuck (i.e., to remove excess moisture) the entire electrostatic chuck should be uniformly heated to completely remove moisture and any other potential contaminants.

Brief Summary Text - BSTX (8):

One solution was to develop a two-piece assembly whereby the chuck and thermal transfer element are individual components and capable of operating at low processing temperatures. In two piece assemblies, the chuck portion resembles a disk-like portion and is commonly referred to as a puck. Usually the puck and thermal transfer element are fabricated from different materials. For example, the puck is fabricated from a ceramic puck (e.g., AlN), while the thermal transfer portion (i.e., cooling plate) is illustratively fabricated from molybdenum or molybdenum alloy, KOVAR.RTM., or a metal matrix composite (Al_{sub}.x Si_{sub}.y SiC). These materials are joined together by brazing. However, brazing temperatures cause thermal expansion to occur at the surface being brazed, which may result in deformation of the puck and cooling plate. For example, the support surface is designed to operate at temperatures in the range of -60.degree. C. to 50.degree. C., and a bake out process occurs in a temperature range of 100.degree. C. to 350.degree. C. As such, the bake out temperature range puts stringent conditions on the types of materials a manufacturer may use to build the electrostatic chuck assembly. In particular, conventional bonding techniques, such as using an Indium alloy, are not reliable in this temperature range due to a low melting point of 156.degree.

C. for indium.

Brief Summary Text - BSTX (9):

Additionally, at extreme operating temperatures, differential thermal expansions of the wafer support assembly components occur. In particular, under thermal load, a material will change shape proportional to the amount of temperature change multiplied by its coefficient of thermal expansion. The coefficient of thermal expansion indicates how much a material shape will change for each degree of temperature change. Typically, a ceramic puck, such as aluminum nitride (AlN), has a thermal expansion coefficient of approximately 5×10^{-6} per degrees C., while stainless steel has a coefficient of thermal expansion of approximately 17×10^{-6} per degrees C. As such, the ceramic puck will expand approximately 3 times less as a similarly sized stainless steel part. When the aluminum nitride and stainless steel are joined together, such thermal expansion differentials may quickly lead to stress and cracking.

Brief Summary Text - BSTX (10):

Another problem is in an instance where molybdenum is used to fabricate the cooling plate. In particular, molybdenum cannot be easily welded to a metal such as stainless steel, aluminum, and the like. Welding molybdenum to stainless steel requires the welding to be performed in a vacuum-like environment. As such, manufacturing difficulties arise when welding a molybdenum cooling plate to a stainless steel pedestal. Furthermore, welding at high temperatures may cause the molybdenum cooling plate to become brittle, thereby increasing susceptibility to fatigue and cracking. Moreover, contaminants may form and combine with the weld, thereby weakening the strength of the bond.

Brief Summary Text - BSTX (11):

Therefore, there is a need in the art for a low processing temperature 300 mm puck and thermal transfer element assembly and a technique for securely joining the puck, cooling plate, and pedestal. Such devices are necessary to improve temperature uniformity across a wafer, maintain the wafer at specific temperature ranges during processing, and reduce the maintenance and manufacturing costs of the same.

Brief Summary Text - BSTX (13):

In one embodiment, the method and resulting assembly include attaching a pedestal joining-ring to a bottom surface of a ceramic puck. Low temperature brazing a composite cooling plate structure to the bottom surface of the ceramic puck, where the pedestal joining-ring circumscribes the composite

cooling plate structure. Thereafter, a pedestal is electron-beam welded to the pedestal joining-ring.

Brief Summary Text - BSTX (14):

In a second embodiment, for a full area temperature controlled assembly, a method and assembly include a ceramic puck having a wafer support surface, and a composite cooling plate structure having a diameter at least equal to the wafer support surface. A pedestal joining-ring is attached to a bottom surface of the composite cooling plate structure. A bottom surface of the ceramic puck is low temperature brazed to the composite cooling plate structure, and then a pedestal is electron-beam welded to the pedestal joining-ring.

Brief Summary Text - BSTX (15):

In a third embodiment, for a full area temperature controlled semiconductor wafer support assembly, a method and assembly include a ceramic puck having a wafer support surface, and a metal matrix composite cooling plate structure having a diameter at least equal to the wafer support surface. A pedestal joining-ring is low temperature brazed to a bottom surface of the composite cooling plate structure. A bottom surface of the ceramic puck is low temperature brazed to the composite cooling plate structure. Then a pedestal is electron-beam welded to the pedestal joining-ring. These and other aspects of the invention will be more apparent from the following description.

Detailed Description Text - DETX (3):

FIG. 1 depicts a partial cross-sectional view of a workpiece processing chamber 100 containing the present invention. The processing chamber 100 comprises a bottom 147, a plurality of walls 146, and a lid 145 to form a vacuum chamber. The processing chamber 100 is illustratively a physical vapor deposition (PVD) processing chamber 100 for processing a workpiece i.e., a semiconductor wafer 102 therein. For a detailed understanding of the PVD processing chamber 100 and its operation in processing a wafer 102, the reader should refer to the drawings and the detailed description contained in commonly assigned U.S. Pat. No. 5,228,501, issued Jul. 20, 1993; and U.S. Pat. No 5,861,086, issued Jan. 19, 1999; which are incorporated herein by reference. These references disclose a 200 millimeter wafer support assembly and a physical vapor deposition chamber manufactured by Applied Materials, Inc. of Santa Clara, Calif. Furthermore, one skilled in the art will recognize that the processing chamber may be any type of chamber for processing a workpiece, such as a chemical vapor deposition (CVD) chamber, etch chamber, and the like.

Detailed Description Text - DETX (4):

The wafer 102 is disposed on a novel apparatus for retaining a wafer (e.g.,

a 200 or 300 mm wafer) against a workpiece support, providing RF biasing to the wafer in a well-defined and insulated path that is internal to the apparatus, and operating in a temperature range of approximately -60.degree. C. to 350.degree. C. Specifically, the wafer 102 rests on a support surface 103 of a wafer support assembly 104. The wafer support assembly 104 comprises a chuck assembly 109 disposed on a pedestal 106. The chuck assembly 109 further comprises a puck 105 (illustratively and hereinafter an "electrostatic chuck") and a cooling plate 107. The electrostatic chuck 105 is disposed on the cooling plate 107 to provide temperature regulation of the electrostatic chuck 105. The pedestal 106 is disposed beneath the cooling plate 107 to support both cooling plate 107 and the electrostatic chuck 105. The electrostatic chuck 105, cooling plate 107, and pedestal 106 together form the wafer support assembly 104. A shaft 126 supports the wafer support assembly 104 at a lower portion 111 of the pedestal 106 from the bottom 147 of the chamber 100. The shaft 126 houses the necessary electrical wiring and plumbing to transfer power (e.g., RF and DC) and heat transfer fluids (e.g., gases and liquids) respectively from various remote sources to the wafer support assembly 104. The pedestal 106 and shaft 126 are electrically connected to ground.

Detailed Description Text - DETX (5):

Although the puck 105 is discussed as being an electrostatic chuck, it need not be such a device. Alternately, the puck 105 may be a heater used in a chemical vapor deposition (CVD) process system (i.e., having no electrostatic chucking capabilities) or any other type of general-purpose workpiece support in a system requiring RF biasing of the workpiece.

Detailed Description Text - DETX (6):

In a physical vapor deposition (PVD) chamber 100, PVD processing is used to deposit a thin film of material on the wafer 102. A target 116 comprising a sputtering or deposition material is positioned over the wafer support assembly 104. The target 116 is electrically insulated from the chamber 100, and may be fabricated from a material such as aluminum, tantalum, titanium, tungsten, or any other material suitable for being deposited as a thin film of the target. The pressure in the chamber 100 is reduced to about 10.sup.-6 to 10.sup.-10 Torr, after which a gas (e.g., argon), is introduced into the chamber 100 to produce a partial pressure ranging between 0.1 mTorr to approximately 20 mTorr.

Detailed Description Text - DETX (7):

A remote DC power source 122 (e.g., a high voltage DC power supply) is electrically connected between the target 116 and wafer support assembly 104 for magnetron sputtering of the target 116. Additionally, a RF (radio frequency) voltage source 124 is coupled to the wafer support assembly 104 as

explained in greater detail below. In one embodiment, one or more rings such as a waste ring 108 and/or a cover-ring 138, and/or a shield 150 circumscribe the electrostatic chuck assembly 109. The waste ring 108, cover-ring 138, and shield help to prevent unwanted **deposition** material from accumulating into a lower chamber region 140, as well as provide uniform wafer processing at the edges of the wafer 102.

Detailed Description Text - DETX (8):

One of the aforementioned heat transfer fluids is a "backside gas", which is provided from a backside gas delivery system 130. The backside gas is transferred to the backside of the wafer 102 from one or more remote gas sources (e.g., gas sources 133 and/or 134) via a gas conduit 142. The gas conduit 142 extends through the shaft 126 and the wafer support assembly 104. The backside gas flows through the wafer support assembly 104 via the gas conduit 42, to a process cavity 148 located directly above the wafer support assembly 104. The backside gas is used to provide sufficiently even heat transfer by direct conduction between the backside of the wafer 102 and the support surface 103 of the chuck 105. The backside gas is typically helium, argon, hydrogen, carbon tetrafluoride, or any other gas that is a good heat conductor at low pressures. The backside gas is usually applied through channels or grooves (not shown) formed in the support surface 103. The channels or grooves may be formed in concentric circles or any other pattern suitable for evenly distributing the backside gas across the backside area of the wafer 102. Additionally, a cooling fluid and/or one or more **heater** elements may be disposed within the cooling plate 107 to also provide **temperature** regulation of the electrostatic **chuck** 105. These additional **temperature** regulation devices are further discussed below.

Detailed Description Text - DETX (10):

FIG. 2A depicts a partial perspective, cross-sectional view of a first embodiment of a workpiece support assembly 104 of FIG. 1. FIG. 2B depicts an enlarged cross-sectional view of a portion of the first embodiment of the workpiece (e.g., wafer) support assembly 104 of FIG. 2A. FIGS. 2A and 2B (collectively FIG. 2) together provide full area **temperature control** for the electrostatic chuck 105. Specifically, the wafer support assembly 104 comprises an electrostatic chuck assembly 109 coupled to a pedestal 106. The electrostatic chuck assembly 109 further comprises the electrostatic chuck 105 coupled to the cooling plate 107. The cooling plate 107 is then coupled to an upper surface of the pedestal 106. The electrostatic chuck 105 may be fabricated from a ceramic material such as aluminum nitride, silicon dioxide, silicon nitride, alumina, and the like. Preferably, the electrostatic chuck 105 is fabricated from aluminum nitride and shaped as a thin circular puck. An

example of a ceramic electrostatic chuck that may be used in this apparatus is disclosed in commonly assigned U.S. Pat. No. 5,656,093, issued Aug. 12, 1997 to Burkhardt, and is incorporated herein by reference. Specifically, that reference discloses a ceramic electrostatic chuck having a wafer spacing mask 202 of a metallic material deposited on the chuck surface 103.

Detailed Description Text - DETX (11):

The electrostatic chuck 105 also comprises a peripheral flange 204, which circumscribes a lower edge of the electrostatic chuck 105. The flange 204 is optionally used to support the waste ring 108 and/or cover ring 138. The waste ring 108, cover ring 138, and peripheral flange 204 together help prevent deposit material from accumulating below the surface 103 of the chuck 105.

Detailed Description Text - DETX (15):

The cooling plate 107 provides temperature regulation for the electrostatic chuck. In the preferred embodiment, the cooling plate 107 and the top surface 103 of the electrostatic chuck 105 have substantially equal diameters. In one embodiment, the cooling plate 107 has a diameter at least equal to the diameter of the support surface 103 of the electrostatic chuck 105. The cooling plate 107 allows for full area temperature control. Specifically, since the cooling plate 107 is disposed beneath and extends in diameter at least the same diameter as the support surface 103 of the electrostatic chuck 105, temperature regulation is provided over the entire area of the support surface 103.

Detailed Description Text - DETX (17):

The cooling plate 107 and electrostatic chuck 105 are low temperature brazed together, using for example an aluminum alloy brazing material, to allow for full area temperature control as beneath the top surface 103 of the chuck 105. Low temperature brazing occurs in a temperature range of 110.degree. C. to 660.degree. C. Brazing at temperatures above 660.degree. C. is considered high temperature brazing. Furthermore, such low temperature brazing provides a hermetic seal as between the electrostatic chuck 105 and the cooling plate 107, which helps maintain the vacuum environment in the processing area from the atmospheric environment within the chuck assembly 109.

Detailed Description Text - DETX (18):

The cooling plate 107 comprises various components that assist in regulating the temperature of the electrostatic chuck 105, as well as assisting in biasing of the workpiece (wafer) 102 during processing. In particular, the cooling plate 107 comprises a body 234, which may optionally function as an electrode. In this instance, the body 234 is coated from a material (e.g., silver or nickel/copper), which is a high conductor of RF power.